Assessment of Direct and Indirect effects of Anthropogenic Aerosols on Regional Climate over East Asia Using a Coupled Regional Climate-Chemistry-Aerosol Model

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ABSTRACT

A regional coupled climate-chemistry-aerosol model is developed and used to assess the various effects of anthropogenic sulfate and carbonaceous aerosols on regional climate over East Asia. Three major types of anthropogenic aerosols are included: sulfate, black carbon and organic carbon; and various aerosol effects are considered, i.e., direct effect, semi-direct effect and 1st and 2nd indirect effects. The model results suggest that the direct effect and 1st indirect effect mainly reduce the solar radiation and hence decrease the surface temperature (~ -0.3K), while the 2nd indirect effect generates a comparable positive long-wave forcing to the negative solar forcing. The 2nd indirect effect increases the cloudiness and cloud liquid water, which has a substantial downward long-wave impact during nighttime, and thus leads to a nighttime warming of 0.5K from the present anthropogenic aerosols loading. This might be responsible for the observed nighttime warming as reported by Zhou et al. (2004) in the industrialized part of China. The simulated precipitation reduction by the combined direct and 1st indirect effect is about -10% in the fall and winter, and less reduction (-5%) in spring and summer. The 2nd indirect effect strongly depends on the auto-conversion scheme, with about 30% in the fall and winter, and -15% in the spring and summer using Beheng (1994) scheme. The semi-direct effect redistributes the vertical temperature structure of atmosphere, and would affect the precipitation pattern over China, but much less reduction (~ -1%) on average comparing to the other effects. In addition, by allowing the interaction between the aerosol and precipitation change in the coupled model, the model-simulated precipitation and aerosols better agree with the observations.